of the atmosphere, and is found to have a very definite position relative to the centre of the cyclone; and this directly confirms the explanation given by Mr. Ferrel of the persistent left-handed rotation of the tornado, as well as of its regular direction of advance. There is no better example than this, of the successful deductive study of meteorology.

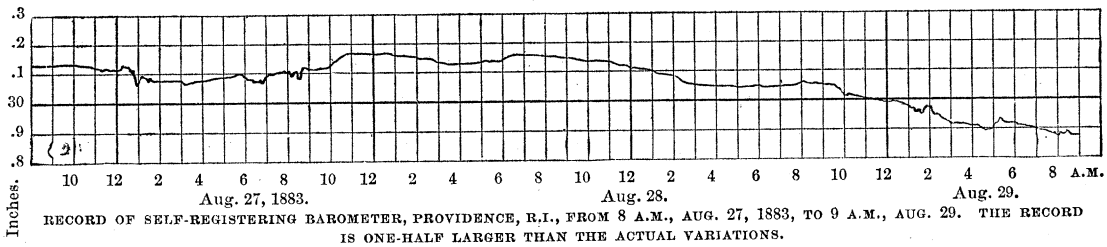
There are, of course, other theories of tornado action still held. The electrical, or, as it may be called, the vague theory is one of the most popular; but fortunately it is condemned by it makes a determined resistance. There it survives for a time as a curiosity, a relic of by-gone days.

LETTERS TO THE EDITOR.

*** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

Atmospheric waves from Krakatoa.

I NOTICE, in your publication of the 14th of March, an account of an atmospheric wave which took place soon after the eruption of Mount Krakatoa. Thinking that it may be of interest, I enclose a copy of a sheet taken from a self-registering barometer that is under my charge. The fluctuations shown by the barometric line upon this sheet are very unusual; but,



RECORD OF SELF-REGISTERING BAROMETER, PROVIDENCE, R.I., FROM 8 A.M., AUG. 27, 1883, TO 9 A.M., AUG. 29. THE RECORD IS ONE-HALF LARGER THAN THE ACTUAL VARIATIONS.

as I was in Europe at the time they occurred, I can only say that the sheet must explain itself, and that the barometer is a very sensitive and reliable one.

EDMUND B. WESTON.

Providence, R.I., April 16.

Your correspondent, 'S.,' in *Science*, No. 63, would seem to be wrong in attributing to the atmospheric waves following the Krakatoa explosion any thing like the character of the rapid waves of compression and expansion which cause sound; for this would be the kind of disturbance referred to as following the explosions of powder-mines, which disturbance generally takes the form of shattering glass windows, and is probably due to the suddenness and unusual amplitude of the first wave of compression, or perhaps to the shivering vibrations set up in the window-sashes, or in the whole sides of wooden buildings. None of these waves could, on account of their frequency, show themselves at all on barometric traces.

In the Krakatoa waves the barograph traces, combined with the velocity of transmission, show that these waves must have been long, smooth swells (varying from fifty to five hundred or six hundred miles in length, with the shorter waves sometimes superposed upon the long ones) something like the ground-swell of the ocean, only with the waves much longer than the latter, and travelling in an elastic medium whose density and pressure vary from that at the earth's surface up to zero.

For the cause of such an unusual condition of the atmosphere, we must examine the results of the new hydrographic survey of the vicinity of Krakatoa, as published in *Nature*, 1884, Jan. 17, p. 268 (also, in part, in *Science*, No. 54, p. 211), and also the data

electricians. The theory of descending winds, or of commotions beginning in the upper air, and then descending to the ground with actual downward currents, has had not a few supporters, but now seems to be defended only by Mr. Faye of the French bureau of longitudes. The last *Annuaire* of this bureau contains a brief repetition of his *Défense de la loi des tempêtes* of 1875, in which he persists in regarding tornadoes and storms in general as down-cast draughts of air, and, strangely enough, finds proof of his statements in the descriptions of western tornadoes published by the signal-service, which make mention of the 'descent of the tornado cloud.' It is quite time that the downward 'growth' of the cloud should no longer be misapprehended, and that the real meaning of this significant appearance, so long ago well explained, should be generally understood. But, before an error finally disappears, it is natural enough to find it restricted, like an organic species on the verge of extinction, to a small habitat, like the Island of Mauritius, or the Bureau of longitudes, where

from the logs of some of the vessels caught in the Straits of Sunda at the time (see *Nature*, 1884, Jan. 10, p. 240).

A careful consideration of the data there available would seem to render it almost certain, that, in this Krakatoa explosion, something like two or three cubic miles, perhaps more, of earth which formed the northern part of the volcanic island and its underlying strata, were blown into the air to some unknown height, and clearing entirely Lang Island, lying immediately north-east, came down again six or eight miles to the northward and eastward. As this probably took place at a single explosion, and as large amounts of gases under enormous pressure were almost certainly suddenly set free, to say nothing of the sudden generation of steam, it is, perhaps, not to be wondered at, that this immediate demand for 'more room' should have started a series of waves in the atmosphere (like those in a mill-pond from the plunge of a stone) which travelled several times round the globe.

The vessels' logs above referred to — one reporting the barometer fluctuating between twenty-eight and thirty inches and violently agitated, and another the same rising and falling from half an inch to an inch in half an hour — show how violent was the local disturbance, which, by the time it reached this country, amounted to only about two millimetres.

Doubtless some slight effect of this kind must follow every large explosion, like that of a powder-mill, over some limited area; and it is worthy of note, that Mr. Scott, the secretary of the London meteorological council, in his paper communicated to the Royal society on Dec. 4, 1883, states that the traces of these Krakatoa waves "exhibit considerable similarity to that of the King's barograph at the Liverpool observatory, at the Waterloo docks pierhead, on the 15th of January, 1864, when the Lottie Sleigh, loaded with about twelve tons of gunpowder, blew up. The ship was lying about three miles from the observatory." But this phase of such explosions is entirely distinct from their sound and their window-shattering character.

H. M. PAUL.

Washington, April 21.

Osteology of the large-mouthed black bass (Micropterus salmoides).

Very recently my studies have required me to make several dissections of the large-mouthed black bass, and carefully prepare two or three skeletons of this fish. These skeletons are now before me, and in two of them I notice a very interesting anatomical point. During the course of my reading upon the skeletons of fishes, I have failed to discover any account of a similar condition in any of the Teleostei, and note it here, trusting that I may learn from others, interested in the anatomy of this class of vertebrates, whether or no they have ever observed the same. This consists in a pair of freely articulated ribs at the base of the occiput. Their heads are received in a shallow facet on either side, situated just above and rather internal to the foramen for the vagus nerve. Immediately below each rib occurs the projection of bone that bears upon its entire posterior aspect one of the pair of articular condyles for the first free vertebra of the spinal column. Still beneath these condyles is seen the conically concave facet for articulation, with a similarly formed surface occurring on the centrum of the vertebra just mentioned, and the one which I believe would be described as the atlas.

This pair of ribs is directly in sequence with the abdominal ribs on either side. Their occurrence in this situation might be accounted for by saying that several of the anterior vertebrae of the column had been absorbed by the occipital elements. Mr. Bridge found such a condition in Amia, though no free ribs were present (*Journ. anat. phys.*, xi. 611, Lond., 1877). In the cranium of Micropterus, however, I should think that this would be highly improbable. Both the first and second vertebra of the spinal column of this bass support each a pair of free ribs, and a mid-series of the other abdominal ribs bears epipleural appendages. Dr. Günther states in his account of the osteology of the Teleostei, in article 'Ichthyology,' of the Encyclopaedia Britannica (vol. xii., 9th ed.), that "the centrum of the first vertebra or atlas is very short, with the apophyses scarcely indicated. Neither the first nor the second vertebra has ribs." I have a yellow perch (Perca americana) in my possession where both of these vertebrae support a pair of free ribs.

Should an examination of the young of the black bass show that none of the anterior vertebrae of the column were included with the occipital segments, but that these ribs are truly occipital ribs, then they become of interest from several points of view.

R. W. SHUFELDT.

Washington, March 31.

Caulinites and Zamiostrobus.

As *Science* has devoted a page of its valuable space to Mr. Joseph F. James's copies of Mr. Lesquereux's figures of these plants and his remarks thereon, in which, without having seen the specimens, he essays to overthrow the determinations of the venerable paleontologist, a word in reply may be justified as tending to correct the impression, already quite prevalent, that the determinations of vegetable paleontologists are in large measure mere guess-work.

As regards Caulinites fecundus, little need be said, since its problematical character was sufficiently insisted upon by Mr. Lesquereux in his description. The 'capsules' are much smaller than those of Onoclea sensibilis, and are found in intimate relation with the stems which have been called Caulinites. The matrix is a light, fine-grained shale, showing the longitudinal, parallel nervation of these stems very clearly. It also contains fragments of dicotyledonous leaves which may have belonged to the plant that bore the fruit; but no ferns are present, as these would be clearly shown by their characteristic nervation. It is safe to say, that, if Mr. James had examined the fossils, he would not have said that there was "no doubt" in his "mind that Caulinites fecundus is nothing but a part of the fertile frond of Onoclea sensibilis."

As regards Zamiostrobus, however, there is 'no doubt' that Mr. James is egregiously in error. His confident statements well illustrate the folly of discussing mere figures of objects that are in existence. He has entirely misapprehended the nature of the specimen; and this is not altogether the fault of Mr. Lesquereux's figure. The fossil is a segment of a zone, cut out of a cylindrical or conical body which must have measured about eight inches in diameter. This segment was placed with the exterior surface upward in the drawing, in order to show somewhat in perspective both this surface and the radiate structure of the cross-section from the direction of the centre. The figure is defective in not showing the manifest angle which all the dark spots have on one side, and which fixes their true character as scars of former leaves. It is probably not a cone, as Mr. Lesquereux supposed, but a fragment of one of those